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Development of Course Modules for Powder Processing Education

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POWDER PROCESSING EDUCATION

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Abstract

Professors and students at Iowa State University are developing a unique flexible modular concept for promoting undergraduate education in powder processing. The approach consists of developing computer-based course modules in specialized processes, which emphasize application and industrial practice before designing model experiments and exploring fundamental concepts. Several such modules are being developed with emphasis on ceramic and metal powder processing.

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Introduction

Recent U.S. government-sponsored studies of the decline of international competitiveness have reported that one of the most severe problems is the lack of education of future engineers in synthesis and processing of advanced engineered materials.(1,2,3) In response, the National Science Foundation has made awards 6 universities to develop materials processing course materials for improving processing education. Iowa State University is among those selected.

Problem Assessment

An informal survey conducted by professors at Iowa State University helped to elucidate the critical needs in processing education. The most commonly cited deficiencies include: the existing curricula is generally outdated and is not relevant to current industrial processes, many programs do not stress the application of fundamental principles to materials processing and, the scope of processing education is often limited to specific areas of resident expertise, and the multidisciplinary nature of materials processing is not conveyed. Discussions with industry representatives added that students were often inadequately prepared in communication and teamwork skills and in creative problem solving-- deficiencies not limited to materials education. Although any one program cannot thoroughly address each of these needs, it is clear that processing education can and must be improved by a concerted effort of leaders in the field. The Materials Science and Engineering Department at Iowa State University has a well established, ABET accredited program offering B.S. degrees in both Ceramic and Metallurgical Engineering. In addition to several faculty working in ceramic processing ISU is uniquely situated near Ames Laboratory, and their tradition of metallurgical expertise. Work on this program began in May of 1993.

Approach

Development philosophy

A common problem with introducing new course material to an existing curriculum is that most programs are considered to be "over-committed" in terms of course topics and time and have very little flexibility. Few departments can afford the curriculum space to introduce an entirely new course in their program, and therefore must depend on introducing new or expanded material in the framework of the already existing courses. Since there is an outstanding variety of programs which include materials processing, flexibility is key. In order to ensure that the materials developed at ISU can benefit the maximum number of students in Materials Science and Engineering, a new approach was developed.

A system involving flexible teaching modules has been designed to respond to the varying needs of existing departments, including that at Iowa State University. Each module is a 4-6 week set of teaching lectures and laboratories which can be used individually or together. This approach addresses the needs not only of the education of students majoring in the field of materials science and engineering, but also in allied disciplines either in the form of service courses taught to non-majors, or materials-related courses taught by other departments.

Computer-based course development was selected as a mode of delivery largely because of its flexibility. Computer based course material (courseware) can be designed such that the modules emphasizing specific processing techniques share common links to fundamental concepts so that each module can be as complete and concise as possible without repeating common material. Courseware also allows great flexibility in the order of presentation of materials, a significant departure from the traditional linear textbook approach. Also, the user can choose the level of the presentation, from basic to advanced. Delivery of courseware over a national network also provides maximum availability to students and educators. Additionally, courseware provides functionality not easily achieved in "hard copy" form. Specifically, color photographs and images, animations, videos, and sounds are easily accommodated. Finally, courseware can be designed to require interactive learning -- the student is asked to answer questions or provide some sort of input in order to proceed. It has been suggested that active learning is more effective for a majority of students than classical passive learning styles frequently associated with lectures or reading a text.(4)

The course modules developed in this program begin by displaying a product with a specific purpose. This goal-oriented approach allows the student to immediately grasp the relevance of the fundamental concepts presented later. Each module refers to 2 or 3 laboratory experiments related to various processing stages. These experiments are designed to clarify fundamental concepts and reinforce their relationship to processing parameters.

Module Specifics

Authorware Professional™ 2.0.0 courseware development software was selected as a vehicle for delivery of these modules for a number of reasons. This software is available for both the Apple Macintosh and IBM-PC compatible platforms, and can be translated from the Macintosh to the PC, utilizing a large fraction of educational computing equipment already in place. This software also allows the "packaging" of programs so that the end product is self-contained. The user does not need to own the software in order to use the product. However, should a professor choose to purchase the software and alter the program, it's intuitive, icon-based programming language is easy to learn. This software also has a full range of multi-media capabilities.

Navigating through the courseware is through pull-down menus and click-touch areas similar to those familiar to most students who have worked either in the Macintosh or Windows-environments. Within each section, push-button forward and backward arrows allow the students review material already presented. There is an optional "help session" available either at the beginning of a session, or at any time during the session which fully describes the use of the program. A "product screen" shows the student the choice of products to select the various modules. After an introduction where the applications and the materials requirements of a particular product are discussed, the student can elect to study the stages of processing in any order. These stages include: raw materials, powder preparation, forming, sintering, and finishing. With the selection of one of these processing stages, another pop-up menu appears with a more detailed breakdown of the topic, which is further linked to a "fundamentals module". Each module also has a section on properties and references to more information. Module-specific problems and experiments can also be accessed at any time. The problems are of various types, including short answer questions, True-False questions, and "assembly" where a student is asked to drag and drop items with the mouse (either labels or pictures) to an appropriate place on the screen (sometimes in a specific order). This particular type of problem is extremely useful for "walking through" a lab experiment and equipment use before going in to lab. The experiments have an introduction, a background and a procedure section, as well as information on safety and handling of the equipment and materials used. Finally, there is a "modeling" section, in which processing can be investigated by changing various processing parameters. In this interactive section, the student investigates relationships between processing and properties by changing processing parameters and viewing the effect on properties. For example, densification kinetics are shown for student - entered temperatures, particle sizes, and diffusion mechanisms.

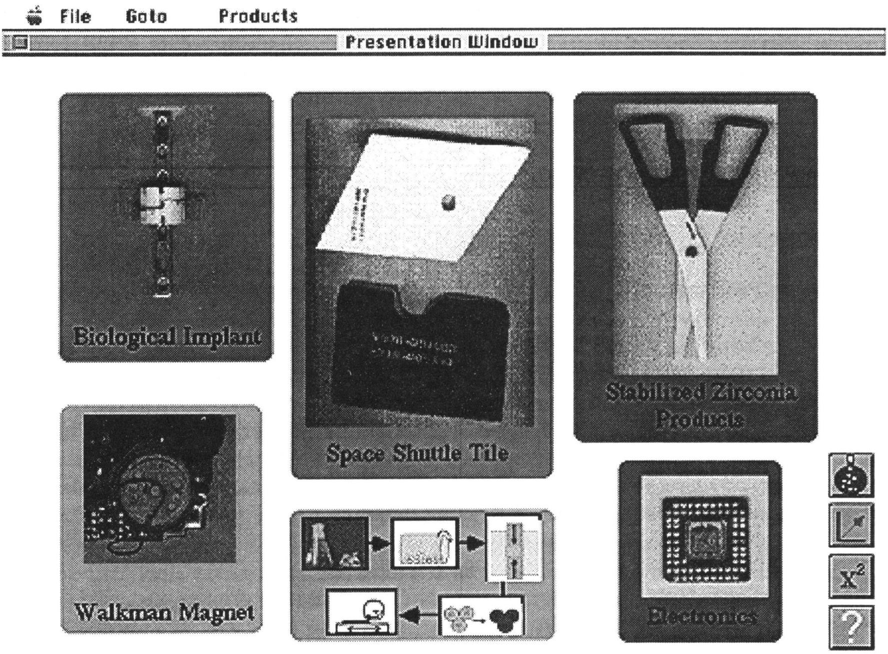

Figure 1 The "Product Screen" for selecting modules. The lower middle area is a generic processing flowchart which accesses the fundamentals modules directly. The small icons at right access (from top to bottom) experiments, problems, modeling and the help screen. The student may also select the options from the "Products" and the "Go to" menu.

Because the processing of various types of materials frequently share common fundamental concepts, each processing stage is also linked to a fundamentals module, which is common to all of the different modules. For example, a student may wish to learn more about sintering after reading about the specifics of the sintering process involved in manufacturing a space shuttle tile. That student could access a fundamental module on "sintering" which includes an illustrated discussion of liquid-phase and solid-phase sintering, an animation of a particular sintering mechanism. (Figure 2) Each of the 6 processing stages has a fundamental module linked to it. The student may also choose to browse through the fundamentals modules separately, without selecting a particular product.

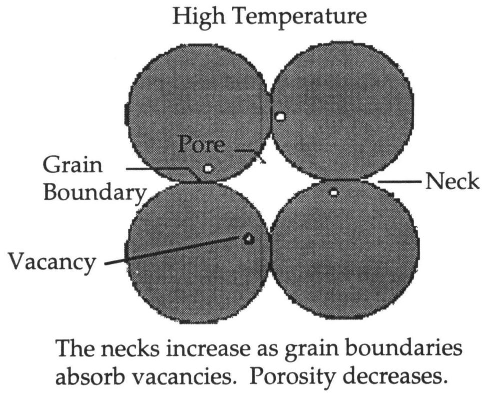

Figure 2. A frame of an animation showing densification by vacancy migration

Progress to Date

Five modules have been developed to date. The selection of the products for these modules was made considering the variety of processing techniques employed, the critical material properties (e.g. mechanical, electrical, magnetic, thermal, and biological properties), and level of interest and accessibility to students. Products selected include: a biological implant, a space shuttle tile, an electronic substrate, zirconia scissors, and a magnetic tape head. (Figure 1) Additional products are being investigated for their applicability to this modular system.

The architecture of the program has been fully developed, leaving remaining efforts focused toward contents. Each module requires more input to provide the content and features for more advanced study - including theoretical modeling of some of the processing stages. Animations and video images of industrial processes have been incorporated into the modules, but more are being actively sought.

Compatibility with various on-line delivery systems is being investigated. When an appropriate system can be identified and a feedback mechanism developed, the courseware can evolve into a dynamic system where changes and additions can be made on a continuous basis.

Constraints and Challenges

Continuity

Although flexibility is the key to this modular system, there are also constraints and challenges associated with it. Since a student may arrive at any given section of the general modules from a number of different paths, these sections must be written in "stand alone" form, in that direct references to previous sections are inappropriate. Because of this constraint, we must rely on the guidance of the professor to help the student make the appropriate associations between related subjects, and maintain continuity.

Specificity

Experimental portions of these modules necessarily relies on the availability of specific equipment. Although we have made an attempt to include general equipment which is probably available in most materials science departments, it is quite likely that some of the experiments cannot be performed in some departments. We will include sample results and reports for experiments which will provide some learning experience (though not hands on), for students in equipment-limited situations.

Module Size

Multimedia computing can provide a rich experience of sight and sound, but can also require sophisticated hardware and large quantities of computer memory. We are attempting to limit file size and use file-compression schemes which would allow even modestly configured computers to use most, if not all of the capabilities of the modules.

Copyright issues

Although these modules will not be sold, there are copyright issues which must be considered especially for use of graphics. Since the laws relating electronic duplication and manipulation of images are not well defined, we have been keeping careful records of the sources of graphics used in these modules. We will seek guidance on these legal aspects, and seek permission when necessary.

Future Work

Development of the 5 existing modules will continue, and the set will be used as a basis for MSE 202 and MSE 206 (Introduction to Materials Processing and Laboratory) at Iowa State University in the 1994 Spring Semester. Student response to these modules will be evaluated through a survey administered at the end of the semester. Modifications will be made to the content and format as indicated.

An instructors guide for module use will be developed before distributing the test product to other universities.

We are currently identifying other universities interested in testing these modules, either separately, or as a group for the 1994 Fall Semester. Again, will request recommendations for improvements.

Summary

Computer - base course materials are being developed for improving materials processing education. Interactive courseware modules incorporating videos, sounds, and modeling have been designed for maximum flexibility and effectiveness. Issues relating to module continuity and distribution are being investigated.

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